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MSAPC ADVISORY CIRCULAR

U.S. ENVIRONMENTAL PROTECTION AGENCY

OFFICE OF AIR AND WASTE MANAGEMENT ● MOBILE SOURCE AIR POLLUTION CONT

SUBJECT: Determination of Engine Families and Classification of Emission Control Systems

A. Purpose

The purpose of this Advisory Circular is to describe how engine families will be determined, and to clarify the definition of emission control system. This Advisory Circular supersedes Advisory Circular No. 20-A which was applicable to the 1975 model year.

B. Background

1. On June 20, 1973, EPA promulgated regulations (38 F.R. 16063) which added catalytic converter and thermal reactor characteristics as bases for grouping vehicles into engine families. Advisory Circular No. 20-A was published on August 10, 1973 to provide guidance as to how engine families and emission control systems would be determined based on specific engine, catalyst, and thermal reactor parameters.

2. At the time Advisory Circular No. 20-A was issued, a limited amount of data existed concerning the durability characteristics of different types of catalytic converters in automotive applications. The eight catalyst parameters identified in Advisory Circular 20-A were based upon the best information available at the time. For the 1976 model year, however, EPA has reassessed the characteristics that should be considered in evaluating catalyst durability, and has concluded that:

a) Packaging of the catalyst, although not a family or control system determinant for 1975, is an important parameter that can significantly affect the durability of a catalyst. Therefore, basic catalyst packaging (e.g., materials, technique of containment and restraint, and general method of construction) has been added as an emission control system determinant.

b) The control system determinant relating to total metal loading was incorrectly worded. The criterion was intended to apply to all active materials and not merely those formulated from noble metals. Therefore, the wording has been changed to read "total active material loading per catalyst".

c) The purpose of the ranges specified under the total active material loading and active material mix determinants was to permit catalysts which varied only to a limited extent to still be grouped together for certification purposes. However, EPA does not have sufficient data to continue to support those ranges, or to set more appropriate ranges. EPA has therefore decided to eliminate the ranges altogether and to substitute a provision by which the vehicle manufacturer may demonstrate the equivalence of catalysts which differ with respect to these determinants. (See (e) below.)

d) Advisory Circular 20-A was ambiguous in regard to whether the substrate construction technique criterion applied to both monoliths <u>and</u> pellets or only to monoliths. Advisory Circular 20-B indicates that the criterion applies to <u>all</u> forms of catalyst supports.

e) To the above criteria, i.e., general catalyst packaging, total active material loading, active material mix, and substrate construction technique, a provision has been added by which a manufacturer can demonstrate essential equivalence. The showing shall be based on prior certification durability data or other test data acceptable to EPA.

f) The 15 percent range has been retained for the catalyst volume criterion. However, a provision has been added by which a manufacturer can demonstrate that catalysts differing in volume by more than 15 percent are equivalent by showing that the active surface areas (BET) of the respective catalysts differ by no more than 15 percent.

3. The criterion which determines families for rotary engines was revised to permit rotor housing widths to differ by up to 15 percent. This change was made to allow rotary engines with limited differences in displacement to be grouped in one engine family, similar to the way reciprocating engines are combined.

C. <u>Applicability</u>

The provisions of this Advisory Circular are applicable beginning with the 1976 model year to gasoline-fueled light duty motor vehicles and trucks, and diesel-powered light duty vehicles and trucks.[1]

1/ Subpart 85.376 is reserved for new diesel-powered light duty trucks. The regulations applicable to these vehicles have not been promulgated at this time. However, reference is made to the respective sections in anticipation of promulgation.

D. Engine Family Determination for Four-Stroke Cycle Reciprocating Engines

1. In order for four-stroke cycle reciprocating engines to be classified in the same engine family, they must be identical in all the following aspects:

a) All the parameters specified in 40 CFR 85.075-5(a)(2), 85.175-5(a)(2), 85.275-5(a)(2), and 85.376-5(a)(2).

b) Engine displacement, within 50 cubic inches or 15 percent of the largest displacement in the respective engine family.

c) General types of fuel system (carburetor or fuel injection).

(1) If carburetion is used, the number of carburetors, number of venturis, and principle of operation (e.g., simple venturi, air valve, and constant depression).

(2) If fuel injection is used, the type (mechanical or electronic) and the flow pattern (continuous or timed).

d) Utilization (or non-utilization) of thermal after-treatment device(s) (i.e., engines equipped with catalysts, engines equipped with thermal reactors, engines equipped with catalysts and thermal reactors, or engines equipped with neither catalysts nor thermal reactors).

e) If catalysts are used, the number and general type of catalyst, which is defined as general purpose (e.g., oxidation, reduction, threeway), general location (e.g., in exhaust manifold, forward underfloor area), general substrate type (e.g., pellet, monolith), proportion of each active constituent of total active material, and catalyst volume (within 15 percent of the largest catalyst volume to be grouped in the same engine family). Catalysts which differ in general substrate type or proportion of each active constituent of total active material may be demonstrated to be essentially equivalent by use of data from completed certification durability testing or other test data acceptable to EPA. Catalysts which differ in volume by more than 15 percent may be shown to be essentially equivalent if the manufacturer can demonstrate that the active surface areas (BET) of the respective catalysts differ by no more than 15 percent.

2. Engines identical in all the respects listed in Section D.1 above may be further grouped into different engine families in accordance with the provisions of 40 CFR 85.075-5(a)(3), 85.175-5(a)(3), 85.275-5(a)(3), and 85.376-5(a)(3).

3. If the requirements stated in Section D.1 above permit engines to be grouped into families in more than one way, engines shall generally be grouped so that each family contains the least variation possible. For example, engines which satisfy all the requirements of Section D.1 but with engine displacements of 200, 250, and 260 cubic inches, would generally be grouped so that the 250 and 260 cubic inch engines make up one family while the 200 cubic inch engine is another family.

E. Engine Family Determination for Two-Stroke Cycle Reciprocating Engines

1. In accordance with 40 CFR 85.075-5(a)(4), 85.175-5(a)(4), 85.275-5(a)(4), and 85.376-5(a)(4), in order for two-stroke cycle reciprocating engines to be classified in the same engine family, engines must be identical in all the following aspects:

a. The cylinder bore center-to-center dimensions.

b. The dimension from the centerline of the crankshaft to the top of the cylinder block head face, i.e., deck height.

c. The cylinder block configuration (air cooled or water cooled; L-6, 90° V-8, etc.).

d. The method of scavenging (valve, port, etc.).

e. The method of air aspiration.

f. The combustion cycle (Otto cycle, Diesel cycle, etc.).

g. Engine displacement, within 50 cubic inches or 15 percent of the largest displacement in the respective engine family.

h. General type of fuel system (carburetor or fuel injection).

(1) If carburetion is used, the number of carburetors, number of venturis, and principle of operation, e.g., simple venturi, air valve, or constant depression.

(2) If fuel injection is used, the type (mechanical or electronic) and the flow pattern (continuous or timed).

i. Utilization (or non-utilization) of thermal after-treatment device(s) (i.e., engines equipped with catalysts, engines equipped with thermal reactors, engines equipped with catalysts and thermal reactors, or engines equipped with neither catalysts nor thermal reactors).

j. If catalysts are used, the number and general type of catalyst, which is defined as general purpose (e.g., oxidation, reduction, threeway), general location (e.g., in exhaust manifold, forward underfloor area), general substrate type (e.g., pellet, monolith), proportion of each active constituent of total active material, and catalyst volume (within 15 percent of the largest catalyst volume to be grouped in the same engine family). Catalysts which differ in general substrate type or proportion of each active constituent of total active material may be demonstrated to be essentially equivalent by use of data from completed certification durability testing or other test data acceptable to EPA. Catalysts which differ in volume by more than 15 percent may be shown to be essentially equivalent if the manufacturer can demonstrate that the active surface areas (BET) of the respective catalysts differ by no more than 15 percent.

2. Under the authority of 40 CFR 85.075-5(a)(4), 85.175-5(a)(4), 85.275-5(a)(4), and 85.376-5(a)(4), engines identical in all the respects listed in Section E.1 above may be further divided into different engine families on the basis of other significant parameters such as those listed in 40 CFR 85.075-5(a)(3), 85.175-5(a)(3), 85.275-5(a)(3), and 85.376-5(a)(3).

3. If the requirements stated in Section E.1 above permit engines to be grouped into families in more than one way, engines shall generally be grouped so that each family contains the least variation possible. (See Section D.3 above for example.)

F. <u>Engine Family Determination for Rotary Engines</u>

1. In accordance with 40 CFR 85.075-5(a)(4) and 85.275-5(a)(4), in order for rotary engines to be classified in the same engine family, engines must be identical in all the following respects:

a) The major axis of the epitrochoidal curve.

b) The minor axis of the epitrochoidal curve.

c) The generating radius of the epitrochoidal curve.

d) The width of the rotor housing, within 15 percent of the widest rotor housing in the respective engine family.

e) The type of intake port (side, peripheral, combination, etc.).

f) The type of exhaust port (side, peripheral, combination, etc.).

g) The housing configuration (air cooled or water cooled; rotor arrangement, etc.).

h) The combustion cycle.

i) The method of aspiration.

j) The number of spark plugs per rotor.

k) General type of fuel system (carburetor or fuel injection).

(1) If carburetion is used, the number of carburetors, number of venturis, and principle of operation, e.g., simple venturi, air valve, or constant depression.

(2) If fuel injection is used, the type (mechanical or electronic) and the flow pattern (continuous or timed).

l) Utilization (or non-utilization) of thermal after-treatment device(s) (i.e., engines equipped with catalysts, engines equipped with thermal reactors, engines equipped with catalysts and thermal reactors, or engines equipped with neither catalysts nor thermal reactors).

m) If catalysts are used, the number and general type of catalyst, which is defined as general purpose (e.g., oxidation, reduction, threeway), general location (e.g., in exhaust manifold, forward underfloor area), general substrate type (e.g., pellet, monolith), proportion of each active constituent of total active material, and catalyst volume (within 15 percent of the largest catalyst volume to be grouped in the same engine family). Catalysts which differ in general substrate type or proportion of each active constituent of total active material may be demonstrated to be essentially equivalent by use of data from completed certification durability testing or other test data acceptable to EPA. Catalysts which differ in volume by more than 15 percent may be shown to be essentially equivalent if the manufacturer can demonstrate that the active surface areas (BET) of the respective catalysts differ by no more than 15 percent.

2. Under the authority of 40 CFR 85.075-5(a)(4) and 85.275-5(a)(4), engines identical in all the respects listed in Section F.1 above may be further grouped into different families on the basis of other significant parameters such as those listed in 40 CFR 85.075-5(a)(3) and 85.275-5(a)(3).

3. If the requirements stated in Section F.1 above permit engines to be grouped into families in more than one way, engines shall generally be grouped so that each family contains the least variation possible. (See Section D.3 above for example.)

G. Definitions of Exhaust Emission Control Systems

Definitions and examples of some currently used exhaust emission control systems are:

1. Engine Modification. A control system which is intended to control exhaust emissions by the design of fundamental engine parameters and components (e.g., carburetion, ignition timing, compression ratio, and combustion chamber design) without the addition of any major hardware (e.g., secondary air pump, thermal reactor, catalysts) or the introduction of an inert material during combustion (e.g., water injection, exhaust gas recirculation).

Note that "engine modification" is a control system used by itself. If major add-on hardware or introduction of inert material is utilized, any related modification to fundamental engine parameters and components will be considered a characteristic of the add-on hardware or inert material system and not an engine modification.

2. Air Injection. A system which is intended to control exhaust emissions by the introduction of secondary air into the exhaust stream. Examples of air injection features which determine different exhaust emission control systems are:

a) General location of injected air (e.g., exhaust port, thermal reactor, catalyst).

b) General method of driving air pump (e.g., constant speed, proportional to engine speed, clutching).

c) Modulation of secondary air flow rate as a function of engine speed and load.

3. Exhaust Gas Recirculation (EGR). A system which is intended to control exhaust emissions by the introduction of exhaust gas into the inlet charge. Examples of EGR features which may determine different exhaust emission control systems are:

a) Location of exhaust gas pick-up (e.g., cross-over, before muffler, after muffler).

b) Point of exhaust gas introduction (e.g., above throttle blade, between carburetor and intake manifold intake port, directly into cylinder).

c) General method of modulating quantity of EGR (e.g., intake manifold vacuum signal, venturi vacuum signal, throttle position).

4. Fuel Injection. A system which is intended to control exhaust emissions by metering and injecting a quantity of fuel either into the intake manifold or directly into the cylinder in order to produce a combustible air/fuel mixture. In accordance with Sections D, E, and F of this Advisory Circular, engines equipped with a particular type (e.g., mechanical or electronic) of fuel injection are not permitted to be in the same engine family as engines not so equipped. Therefore, use of fuel injection determines a separate engine family and also characterizes a control system in the engine family.

5. Catalyst[2/]. A system which is intended to control exhaust emissions by promoting a chemical reaction to convert regulated exhaust gas constituents to other substances. In accordance with sections D, E, and F of this Advisory Circular, engines equipped with a particular type (e.g., oxidation, reduction, threeway) of catalyst are not permitted to be in the same engine family as engines not so equipped. Therefore, use of a catalyst determines a separate engine family and also characterizes a control system in the engine family. Catalyst features which determine different exhaust emission control systems within an engine family are:

a) Substrate (all types) construction technique (e.g., extruded, laid-up, formed).

b) Basic catalyst packaging (e.g., materials, technique of containment and restraint, and general method of construction).

c) Total active material loading.

Catalysts which differ in any of the three parameters designated above may be demonstrated to be essentially equivalent by use of data from completed certification durability testing or by other test data acceptable to EPA.

6. Thermal Reactor. A system which is intended to control exhaust emissions by providing a high temperature environment in an enlarged volume where the oxidizing reactions can continue. In accordance with Sections D, E, and F of this Advisory Circular, engines equipped with a thermal reactor are not permitted to be in the same engine family as engines not so equipped. Therefore, a thermal reactor may determine a separate engine family and also serve as one of the control systems utilized in the engine family. Examples of thermal reactor features which determine different exhaust emission control systems within an engine family are:

2/ See Appendix for additional information.

a) Reactor lining and material.

b) Cooling (if any).

c) Effective interior volume (within 15 percent of the largest volume within the respective control system).

d) Internal reactor configuration (open, baffled, etc.).

e) General location (directly adjacent to cylinder head, downstream, etc.).

7. Mixed System. An exhaust emission control system which is a unique combination of individual control systems. Examples of such mixed exhaust emission control systems are:

a) Air injection + EGR.

b) Thermal reactor + Air injection.

c) Catalyst + EGR.

H. Definition of Evaporative Emission Control Systems

Definitions and examples of some current evaporative emission control systems are:

1. Canister. A system which is intended to control evaporative emissions by storing fuel vapors in a carbon-filled canister.

2. Crankcase. A system which is intended to control evaporative emissions by storing fuel vapors in the engine crankcase.

I. New Emission Control Systems

EPA expects that new devices and control techniques will be developed and utilized as the state of emission control technology advances. These new approaches to emission control will be defined as new emission control systems based upon similarity of components and modifications designed to control emissions.

APPENDIX

The following chart summarizes the effect of catalyst parameters on the determination of engine families and exhaust emission control systems:

Catalyst Parameter	Determines Engine Family	Determines Control System
1. Number of Catalysts	X	
2. General Purpose (e.g., oxidation, reduction, threeway)	X	
3. General Location (e.g., in exhaust manifold, forward underfloor area)	X	
4. General Substrate Type (e.g., pellet, monolith)	X	
5. Substrate (all types) Construction Technique (e.g., extruded, laid-up, formed) 3/		X
6. Basic Catalyst Packaging (e.g., materials, technique of containment and restraint, and general method of construction) 3/		X
7. Proportion of Each Active Constituent of Total Active Material 3/	X	
8. Total Active Material Loading per Catalyst 3/		X
9. Catalyst Volume (within 15 percent of the largest catalyst volume in the respective engine family) 4/	X	

3/ Catalysts which differ in the parameter designated may be demonstrated to be essentially equivalent by use of data from completed certification durability testing or other extensive test data acceptable to EPA.

4/ Catalysts which differ in volume by more than 15 percent may be shown to be essentially equivalent if the manufacturer can demonstrate that the active surface areas (BET) of the respective catalysts differ by no more than 15 percent.